

Total Vehicle Alignment

Vehicle alignment settings serve several purposes in vehicle operation. They affect handling, steerability, stability and have a significant impact on tire performance.

Camber settings are not considered adjustable in the field.

NEVER ATTEMPT TO ADJUST
THESE SETTINGS BY BENDING
OR MODIFYING AXLE/STEERING
MECHANISM COMPONENTS.

The long treadwear potential offered by modern radial linehaul truck tires can be reduced by the misalignment of tractor and/or trailer wheels and axles. Extensive research has demonstrated that total vehicle alignment programs can pay dividends in extended tire wear and improved fuel economy.

There has been increased attention to proper truck alignment procedures during the past few years, and for good reason. Current radial steer axle tires provide a much slower rate of wear than earlier generation radial or bias ply tires. This also means that they may reflect the adverse effects of improper alignment that was unseen on faster wearing tires.

Opinions on proper alignment for radial tires often seem as varied as the number of authorities giving them. For this reason, Goodyear has been actively involved in working toward industry wide agreement to define the effects of improper alignment on tire wear, durability and vehicle handling, and to establish recommended alignment settings.

Much of this work is being directed through industry associations including The Maintenance Council of American Trucking Association, The Society of Automotive Engineers and with individual OEM truck, axle and suspension manufacturers.

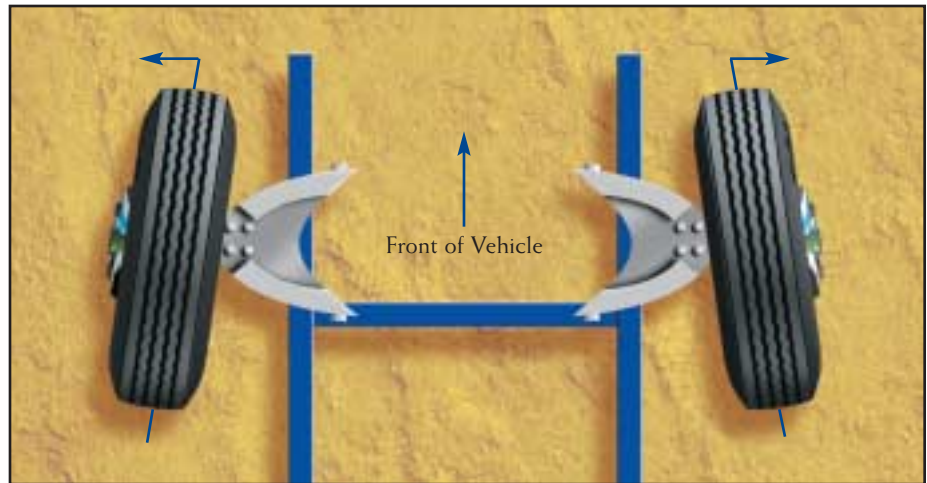


Figure 6.1 Toe-in

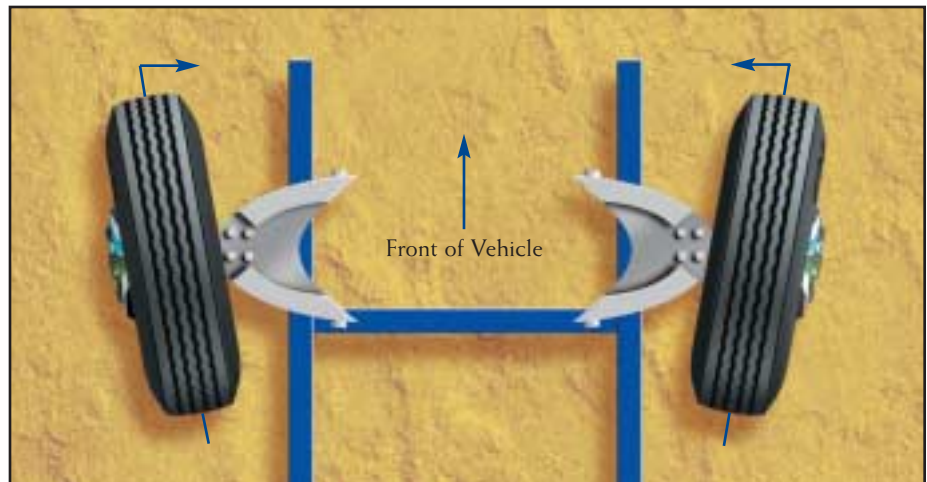


Figure 6.2 Toe-out



Figure 6.3 Positive camber

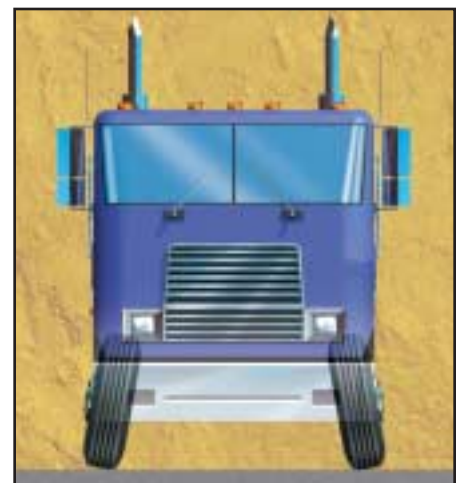


Figure 6.4 Negative camber

In particular, certain truck and axle manufacturers have responded to the requirements for more precise alignment settings. These OEM's do not recommend delivery realignment of their vehicles at the dealer level.

Specific irregular wear patterns and their causes are discussed in detail in the "Irregular Wear" section of this service manual.

Years ago, alignment meant simply a "front-end job". But the steer axle is only the beginning of the total alignment story in the radial age.

We now know that proper attention to drive axles, trailer axles and dolly axles completes the picture. Not only does alignment affect tire wear, but the amount of fuel used by a truck/trailer combination as well. (See Section 9 for additional details).

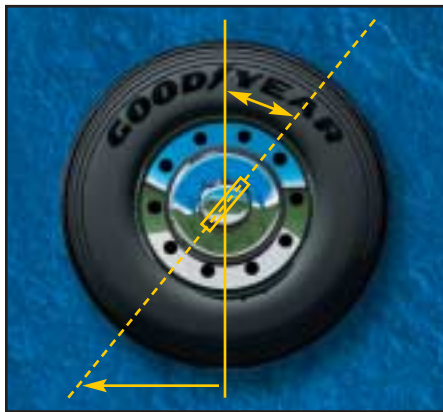


Figure 6.5 Caster

STEER AXLE ALIGNMENT

The major front-end alignment settings involve:

Toe:

Toe is defined as the difference in distance apart, at the front and at the rear, of the steering-axle tires as seen in a top view of the truck. Toe-in exists when the tires are closer together in the front than in the rear **Figure 6.1** and excessive toe-in results in feather wear in the direction shown by the arrows. Toe-out exists when the tires are closer together in the rear than in the front **Figure 6.2** and excessive toe out results in the feather wear in the direction shown by the arrows.

Camber:

Camber is the tilt of the tires as seen in a front view of the truck. Positive camber exists when the tires are closer together at the bottom (point of road contact) **Figure 6.3**. Negative camber exists when the tires are closer together at the top **Figure 6.4**.

Caster:

Positive caster is provided by a backward (rotational) tilt of the top of the axle or backward inclination of the kingpin at the top as seen in a side view of the truck **Figure 6.5**. Negative caster would be a corresponding tilt forward at the top.

Before any alignment adjustment is performed, always check the vehicle for loose kingpins, worn wheel bearings, tie rod ends, or any looseness in the steering system. Adjust wheel bearing end play in accordance with the recommendations of the OE manufacturer. Attempts to correct alignment on a vehicle with worn or loose components are pointless.

LOADED VS UNLOADED ALIGNMENT SETTINGS

Alignment changes as load changes, especially steer axle camber, caster and toe. Since springs, axles and suspension mountings vary by truck and components with different weight ratings are often chosen, different unloaded truck alignment settings may be required to obtain optimum loaded truck alignments.

On steer axles, toe and camber settings are related and should be considered together for optimum tire life, especially in line-haul service where treadwear rates are slow. Positive camber (refer to illustration) creates a slightly shorter rolling radius on the outside shoulder of a radial tire than on the inside shoulder. This creates a tendency for the tire to roll toward the outside—a toe-out condition. Since all the working tolerances in the tie-rod ends and kingpins must be taken up before the tendency to toe-out is restrained, an initial static toe-in setting is essential.

NOTE

Alignment recommendations may need to be "customized" for certain vehicle/tire/service conditions.

TOE

Toe settings generally have the greatest effect on truck tire treadwear. Toe is also the easiest front-end alignment variable to adjust in the shop.

Road tests were made using three trucks with different amounts of loaded truck toe-in (1/32-inch, 1/8-inch and 1/4-inch) with radial tires on the steering axles.

The test results showed:

- Tire tread mileage decreases with increased toe-in. The 1/32-inch toe-in showed the best treadwear rate (miles per 32nd of tread depth).
- Assigning a value of 100 to the treadwear rate with 1/32-inch toe-in, the treadwear rate values compared as follows:

Loaded Toe-in Value (Inches)	Comparative Treadwear Rates
1/32	100
1/8	82
1/4	76

In addition to wear, drivers' reactions to the toe-in settings, without power steering indicated that the 1/4-inch toe-in caused the truck to "roadwalk" badly. The 1/32-inch value was considered to have the best handling.

Tire wear due to excessive toe-in on radial tires shows up initially as irregular wear — more so on the outside than the inside grooves of the tires and more so on the right-front than on the left-front tire. Excessive toe-out will show a reversed effect: more wear on the inside than the outside grooves and more so on the left-front than the right-front tire.

At high values of toe-in or toe-out and at relatively early mileage, the tread of the outside or inside ribs can be completely worn away. For 5/16-inch toe-in condition this can occur after only 19,000 miles of highway travel.

Gauges for measuring toe-in setting are relatively simple and inexpensive. Every maintenance shop should use them frequently. It is not necessary to send a truck to an alignment shop to check toe-in settings.

Setting toe alone is usually not sufficient. A total vehicle alignment (toe and axle) is recommended per TMC RP642.

CAMBER

After years of recommending camber settings of +1/4 degree for left front and 0 degrees for right front, major axle manufacturers have changed to 0 degree settings for both left and right steer axle positions on axles designed for line haul service.

The objective of this change is to optimize steer tire wear and minimize or eliminate irregular wear. Theoretically, these new settings will result in steer tires running straight down the road in a 0 toe/0 camber mode. Goodyear Proving Ground tests and independent field tests support this theory.

Tires with excessive camber will wear as shown in **Figure 6.6**. It can be seen that improper camber causes wear on one side of the tire, this can be on the inside or outside of the tire depending on camber setting and tire position (LF or RF).

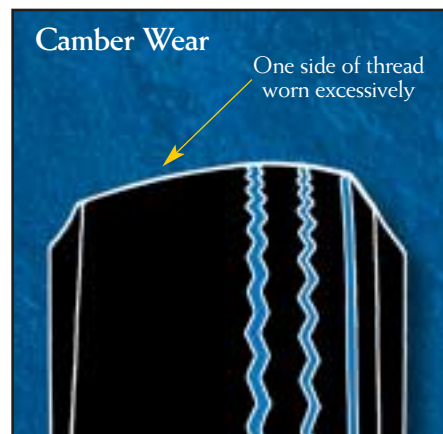


Figure 6.6

CASTER

Generally, caster is not considered to affect tire wear, but is important in the handling and driveability of the vehicle.

Overall effects of caster can be summarized as follows:

—Too little caster causes:

- Unstable steering
- Constant corrections required
- Wander and weave
- Oversteer
- Failure to return to straight ahead out of a turn
- Roadwalk

—Too much caster causes:

- Hard steering
- Shimmy
- Road shock

Vehicle manufacturers normally recommend caster settings for their vehicles. Proper caster is that which gives best handling in combination with the camber and king pin inclination designed into the axle.

ACKERMANN STEERING EFFECT ON TIRE WEAR

There are many variables to check when determining the source of irregular tire wear patterns. One potential cause for irregular wear on steer tires may be a truck's "Ackermann" characteristic.

The Ackermann Principle states that for any given corner, the outside wheel should have less turn angle than the inside one, because it is following a larger radius than the inside wheel **Figure 6.7**.

This difference in wheel turning angles is determined by the length and angle of the steering arms that are attached to the hubs of the steer axle.

The theoretical Ackermann angle for a particular vehicle is determined by drawing a line through the pivoting axis

(which is the rear axle of a two-axle vehicle) to establish a pivot point for a turn; then drawing lines to the pivot points of the two steer tires. The Ackermann, then, is the angle the tires/wheels needed to be turned to form a right angle with each of the lines extending from the turning pivot point to the tire/wheel pivots. This results in the steer tires "toeing out" when turning. A vehicle's wheelbase is the most critical variable affecting the "theoretical Ackermann" for a vehicle.

Keep in mind that Ackermann is a purely geometric concept. The argument that the Ackermann Principle was developed in the early 1900's for very slow-moving vehicles and does not

consider the dynamic effect of many outside influences on the path a vehicle takes through a turn is somewhat correct.

To further complicate the Ackermann Principle as it applies to trucks, remember that the turning axis must be drawn to determine a pivoting point about which the vehicle turns. It's more difficult to define this axis for vehicles with more than one drive axle. Fifth wheels, depending on their location, can also alter where this line would fall.

The trend is for vehicle manufacturers to provide different Ackermann arms for different wheel bases and different fleet vocations.

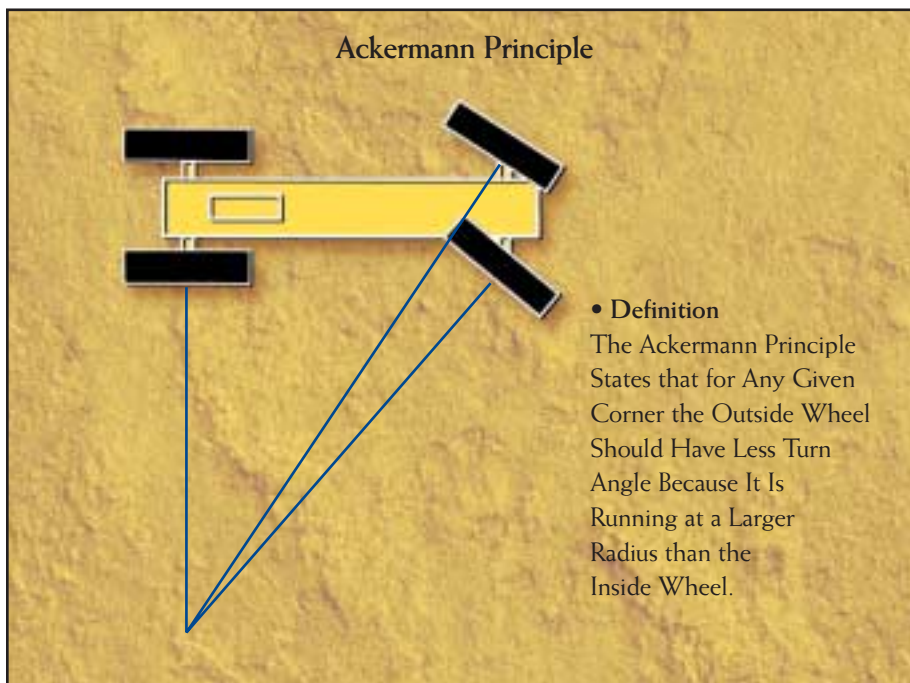


Figure 6.7

DRIVE AXLE ALIGNMENT

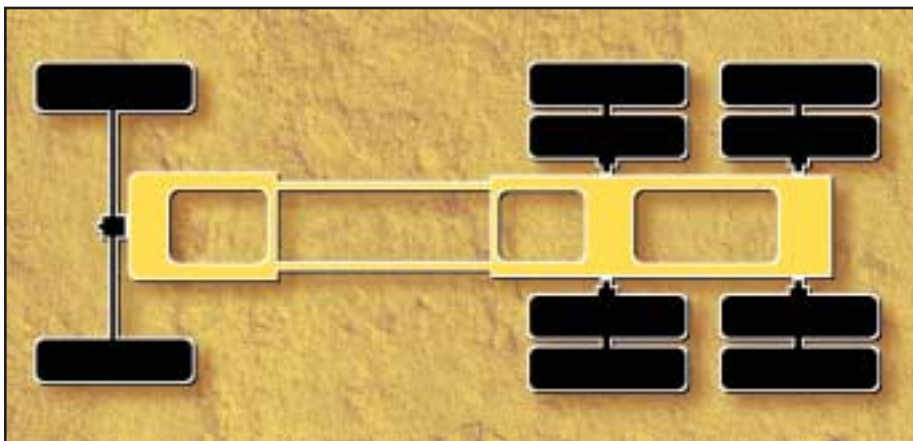


Figure 6.8

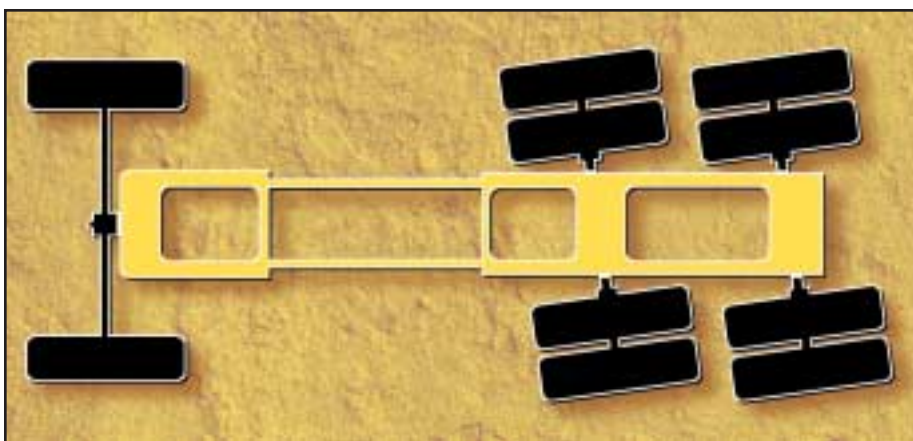


Figure 6.9

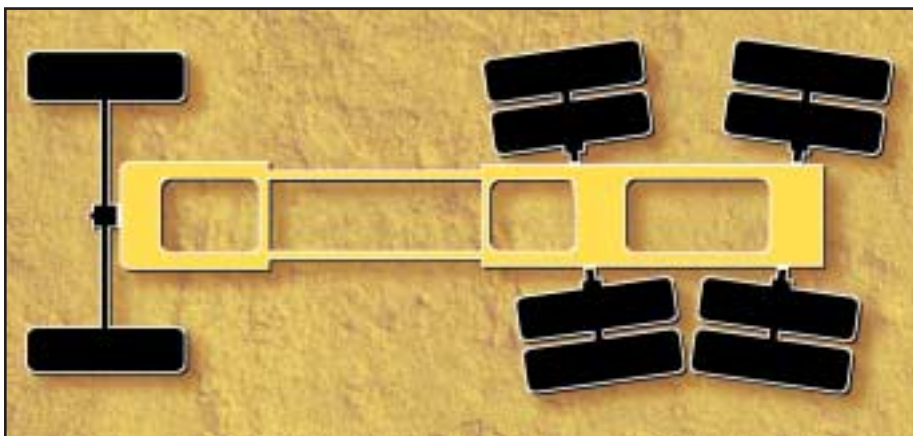


Figure 6.10

Drive axle alignment is very important. Tandem drive axles that are not parallel to each other have a definite effect on steer-tire wear.

Figure 6.8 shows a model of a tandem-drive-axle tractor with both drive axles in proper alignment. In this case, the driver simply steers the truck straight ahead and neither fast wear nor irregular wear would be expected as a result of the driving axles.

However, Figure 6.9 is an exaggerated view of a truck with drive axles parallel, but not perpendicular, to the chassis centerline. The eight driving tires create a "thrust angle" to the left at the rear of the truck. Turning the steering wheel slightly to the left aligns the steer and drive tires to run parallel, but the vehicle however will "dog track." Even though lateral forces on the steer tires are minimal, the steering geometry is affected, which may result in asymmetrical steer tire wear.

A more severe case is shown in Figure 6.10. Here the drive axles are neither parallel to each other nor perpendicular to the chassis centerline. The drive-axle tires are trying to force the vehicle to turn left and the driver must compensate by turning to the right. This will result in fast and irregular wear and, as recent tests have shown, in a much more severe way than the previous case. These tests also indicated that the steer tire on the same side of the truck on which the drive tires are closest together will wear into an out-of-round condition as well.

Recommendations for drive-axle alignment are as follows:

- Tandem axles should be parallel within 1/8-inch difference between the axles centers measured on the left and the right side of the vehicle. Figure 6.11
- Axles should be perpendicular to the chassis centerline within 1/8-inch measured between axle end and vehicle centerline. Figure 6.12

TRAILER AXLE ALIGNMENT

With more long-wearing radial tires being applied to trailer axles, their alignment has become an important issue. Trailer-axle tires have the potential for longer life (more miles per thirty-second inch of treadwear) than any of the tires on the tractor. They are, therefore, more susceptible to irregular wear due to misalignment than any other tires on the vehicle.

Goodyear's recommendations for trailer alignment are as follows:

Preferred toe setting:

1/32-inch toe-in to 1/32-inch toe-out, or ± 2.7 minutes per spindle.

Acceptable toe setting:

1/16-inch toe-in to 1/16-inch toe-out, or ± 5.4 minutes per spindle.

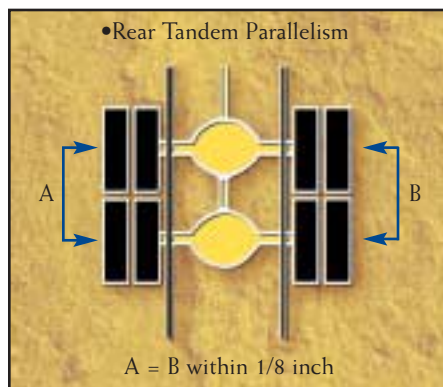


Figure 6.11

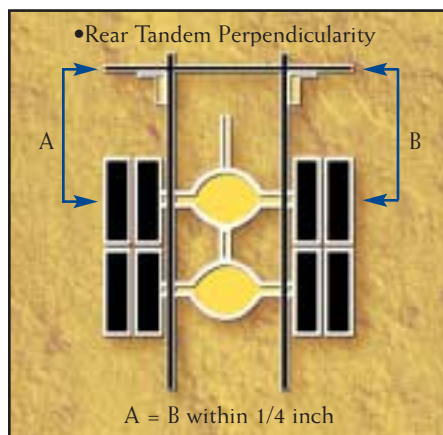


Figure 6.12

The loaded axle camber can be up to negative 1° without affecting tire wear.

Axes should be parallel to each other within 1/8-inch measured between axes on both sides of the trailer at a 71.5-inch axle track. This provides a scrub angle of $\pm 0.1^\circ$.

Axes should be perpendicular to the centerline of the trailer frame within 1/8-inch per side or 1/4-inch from side to side at a 71.5-inch axle track. This provides a thrust angle of $\pm 0.2^\circ$.

IN-SERVICE ALIGNMENT RECOMMENDATIONS

Toe-in is recognized throughout the industry as the most important contributor to optimizing steer tire treadwear. In order of priority, gains in tread life can be expected by focusing on the following vehicle alignment parameters:

- TOE
- REAR TANDEM PARALLELISM
- CAMBER (NON-ADJUSTABLE)
- REAR TANDEM PERPENDICULARITY
- CASTER

Most vehicle manufacturers, in recent years, have developed new factory equipment and procedures to control alignment to much narrower tolerances than was previously possible. Today there is less need to adjust alignment on new vehicles than in the past.

Alignment accuracy and repeatability can best be achieved by proper training, adherence to strict procedures and by properly maintaining and frequently calibrating alignment equipment.

THE VEHICLE MANUFACTURER'S ALIGNMENT SPECIFICATIONS SHOULD BE ADHERED TO.

The following guidelines have proved to be beneficial for improving overall tire treadwear:

STEER AXLES

TOE IN (unloaded):

Check Limits* $1/16'' \pm 1/16''$
(Range 0-1/8'')

Reset Limits $1/16'' \pm 1/32''$

*When alignments are found within these limits, adjustment is not necessary. If outside of check limits, set to the reset limits.

DRIVE AXLES

Tandem axles to be parallel within 1/8" measured at axle end.

Axes to be perpendicular to chassis centerline within 1/8" when measured from axle end to chassis centerline, or within 1/4" when measured from left to right axle end.

TRAILER AXLES

Tandem axles to be parallel within 1/8" measured at axle end.

Axes to be perpendicular to chassis centerline within 1/8" when measured from axle end to chassis centerline, or within 1/4" when measured from left to right axle end.

Nominal toe setting:

$0'' \pm 1/32''$

Reference TMC Recommended Practice RP642 regarding total vehicle alignment for more detailed information.